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RULES FOR THE MANAGEMENT OF A LOCOMOTIVE ENGINE

BY C.H.GREGORY C.E

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PRACTICAL RULES

FOR

THE MANAGEMENT

OF A

LOCOMOTIVE ENGINE;

IN THE STATION, ON THE ROAD, AND IN CASES
OF ACCIDENT.

BY

CHARLES HUTTON GREGORY,
CIVIL ENGINEER.

LONDON: JOHN WEALE.
1841.

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PREFACE.

The substance of the following pages was written several months since, and subsequently sent to the Institution of Civil Engineers, where it was read in abstract on the 16th of February in the present session.

While our Engineering Literature contains several valuable Treatises on the Theory and Construction of the Locomotive Engine, it has, as yet, produced no work illustrating its Use. This circumstance, added to the recommendation of several competent authorities, has induced the writer to apply to the Council of the Institution of Civil Engineers for permission to lay before the public these Practical

Rules for the Management of a Locomotive Engine, drawn up from individual experience, in the hope that they may be acceptable, at a period when any subject connected with the efficiency and safety of Railway travelling is deservedly engaging attention.

At the end of the Paper will be found some Regulations for the first appointment of Engine-men, adopted by the Directors of the London and Croydon Railway, and framed by the writer in his official capacity as their Resident Engineer. Also, a Table of Railway Velocities, indicated by the time occupied in passing over given distances, which he has frequently found to save him the trouble of calculation, and which he hopes may be similarly useful to others.

CHARLES HUTTON GREGORY.

London, March, 1841.

PRACTICAL RULES, &c.

THE MANAGEMENT OF A LOCOMOTIVE ENGINE IN THE STATION.

THE careful examination of a Locomotive Engine when in the Station, and its judicious management while running, are essential to the full performance of its duty, and to ensure the safety of the passengers by the train.

While an Engine is stopping at the Station before a trip, the fire should be properly kept up,—the tubes clear at both ends,—and the fire-bars picked free from clinkers: the regulator should be closed and locked,—the tender-break screwed down tight,—the reversing-lever fixed in the middle position, so that the slides may be out of gear,—the cocks of the oil-vessels and feed-pipes turned off,—and the steam blowing off from the safety-valve at a pressure of 35 ℔s. per square inch; if blowing off in any excess, the waste steam may be turned into the Tender-cistern to heat the water, and the door of the smoke-box may be opened to check the fire, but it should be fastened up again 10 or 15 minutes before the time of starting.

Before an Engine starts with a train, the attention of the Engine-man should first be directed to its being in complete working order; with this view he should go beneath the Engine, and carefully examine the working gear in detail.

The connecting-rod is a very important part, and more liable perhaps than any other to fail for want of proper examination. The cotters must be secure, and in case the brasses have too much play they must be tightened up;

observing, however, that brasses should never be set so hard as to cause friction. If there are set-screws at the side of the cotters, they should be tight, and all cotters should have a split-pin at the bottom for greater security. The cotters which fasten the piston-rods to the cross-heads should be firm in their place, as well as the set-screws, keys, or other connections, by which the feed-pump pistons are secured to the piston-rod.

The brasses of the inner framing which carry the inside bearings of the cranked axle must be examined, and any considerable play prevented by screwing them up if necessary. The wheels ought to be accurately square and firm on their axles, and the keys driven up tight. All the pins, bolts, &c., by which the slide-valve gear is connected, the lifting-links, and the slings of the slide-spindles, must be secure in their proper places; the spanners ought to be fast on the lifting and weigh-bars, and the studs on the spanners of the weigh-bars should be particularly noticed, as, if loose, they may be shaken off on the road and cause the stoppage of the Engine. A similar examination must be extended to the hand-gear, if there be any; and the bolts which fasten the plummer-blocks of the weigh-bars, &c., must be screwed up if they are loose.

The straps of the eccentrics should work with sufficient freedom, and the eccentrics must be firm in their right position on the axle, or the Engine will beat unevenly: if any escape of steam has been observed in the stuffing-boxes of the piston-rod and slide-valve spindle, or of water from the joints of the feed-pumps and suction-pipes, they must be screwed up; and any dirt that may have collected near any of the bearings or connections must be carefully wiped off with cotton waste.

The inspection beneath the Engine being complete, the Engine-man should examine the ends of the tubes of the boiler, and if there should be leakage to any serious extent, it would be prudent to drive in a plug at each end of the defective tube. A small quantity of Russian tallow should occasionally be introduced into the steam-chests and cylinders, to grease the slides and pistons. This is done, either by cocks on the outside of the smoke-box or in the cylinder covers, or through holes secured by plugs, in the steam-chest covers. The ashes should be emptied out of the smoke-box, and the small ash-door carefully secured.

Occasionally the gauge should be applied to the wheels, and the Engine should never be allowed to run when they are found to be at all incorrect or out of the square.

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running 30 miles with certainty; but when the gradients are steep, the load heavy, and stoppages frequent, additional water may be oftener required; and on the other hand, with light duty, an Engine may sometimes run further without any stoppage. The inconvenience attached to the necessity of frequent stoppages, and the expense of maintaining a large number of coke and water stations, have lately induced the manufacture of a larger class of Tender on six wheels, which, from superior capacity, will admit of a much longer run.

After a little practice, the examination described above occupies a very short time: it ought to be completed, and the Engine in its position at the head of the train, at least five minutes before the hour of starting, when oil must be copiously supplied by the small oiling-can, to the oil-cups of the guides, connecting-rods, &c., and to all rubbing parts not fed by the oiling-pipes; the cocks of the large oil-vessels must be opened, and the safety-valve screwed down to the working pressure, say 45 lbs. per square inch.

It would ensure a careful inspection, if, before any train starts, the Engine-man were required to deliver to the Superintendent of the Station a certificate that he has examined his Engine, and finds it in good working order.

Several articles should be constantly carried on the Tender, as either being frequently required in the working of the Engine, or occasionally in cases of derangement or accident. The following may be taken as a list:

One large can of oil, and one or two small oiling-cans and an oiling-tube, a box of Russian tallow, a quantity of *cotton waste,* hemp, and gasken, a *hand-brush,* keys fitted to all the principal bolts, one large and one small monkey-wrench, rods for clearing the tubes and fire, an arrow-headed poker, a shovel, and a rake.

A number of iron or wooden plugs, an iron plug-holder, and a 7℔. maul, two cold chisels, a hammer and a file, spare washers, and duplicates of the principal bolts, nuts, pins, cotters, &c., a quantity of thick and thin cord, and some tarred line, a fire-bucket, two long crow-bars, a spare coupling-chain, with shackle and hook complete, several wooden wedges, about 2 feet long, 4 or 5 inches wide and 3 inches thick, and, if running long journeys, two spare ball-clacks, and a screw-jack.

THE MANAGEMENT OF A LOCOMOTIVE ENGINE ON THE ROAD.

In the management of a Locomotive Engine, many unforeseen circumstances may occur, requiring the use of that discretion which experience alone can confer, and which it would be almost impossible to comprise in the particular instructions contained in the following pages, which, however, the writer believes to contain all the leading principles of Engine-driving.

On receiving the signal to start, the Engine-man should only slightly open the regulator, and let the train run for several yards, before he opens it, by slow degrees, to the full extent. The object of thus giving a slight aperture to the regulator in starting, is to avoid any jerk to the carriages, by which passengers might be annoyed, or even the coupling-irons broken; to prevent the slipping of the driving-wheels, from their adhesion being unequal to the inertia of the train, when the full power of the Engine is suddenly used; and because fully opening the regulator at starting generally causes the Engine to *prime* considerably, from the quantity of water condensed in the cylinders and steam-passages while the Engine was standing. When *priming* occurs at starting, the discharge-cocks of the cylinders should be opened to remove the water. On leaving the station, and frequently on the road, the Engine-man should watch the train behind him, to see that it is all right and its motion regular.

The Engine-man should now be standing on the foot-board of the Engine, which he ought never to leave, unless the machinery is out of order, when he may leave the Stoker in his place; he should as much as possible be in such a position as to command, without moving from his place, the reversing-lever, the whistle, and the regulator, these being the parts *which he* is most frequently obliged to use at the shortest notice; his hand should be upon the regulator, which, when he has arrived at a good speed, he will gradually ease off, so as to economise steam without retarding the train: his eye should be constantly directed to the rails in front of him, that he may be immediately aware of any obstruction, and at the same time his full attention must be given to the maintaining a sufficiency of steam at an equable pressure; this is to be done by using the requisite care in the manner and time of supplying *water* and *fuel.*

Water is supplied by opening the cocks in the feed-pipes, which allow the pumps to act; and the height of water in the boiler is commonly shown by a glass gauge-tube, and by three gauge-cocks at the side, which should *be opened* from time to time, (*especially when* stopping,) as they afford a more correct indication of the quantity of water and steam than the gauge-tube.

One pump, if constantly at work, would, in most Engines, supply as much, or rather more water than is required by the Engine as equivalent to the steam consumed; so that by turning on or off either or both pumps, the Engine-man has the power of regulating the height of the water in the boiler at discretion.

It may be laid down as an invariable rule, that water alone should always blow off from the bottom cock (which is from 1 inch to 1½ inch above the top of the fire-box), in order that there may be enough water over the fire-box and tubes to prevent their burning; and few Engines will carry their water much above the top cock without *priming*, so that the height of the water may be *made to* range between these two

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the Engine starts: a knowledge of this fact also shows the necessity of the water being above the ordinary level, before a decrease is allowed in the pressure of the steam.

When the Engine is highest on an inclined plane, rather a greater height of water must be kept over the fire-box than on a level, in order that the chimney ends of the tubes may be well covered.

The most favourable time for allowing the feed-pumps to act, is when the steam is blowing off with force from the safety-valve, and the fire strong; and the least favourable time is when the steam and fire are low: indeed the Engine-man should manage that it may never be necessary in the latter case, as the addition of water rapidly lowers the steam.

In order to know the force of the steam, one hand may occasionally lift or depress for a moment the lever of the safety-valve, according as the steam is under or over the working pressure; and a little practice will soon enable a person to judge the extent of excess or deficiency.

Both feed-pumps should not commence working at the same time.

The water should never be allowed to run low before arriving at any part of the road where considerable power is required, as steam is produced more rapidly when both pumps are turned off,—a measure which is imprudent unless the water is high.

When "the feed" is turned on, the Engine-man should try the pet-cock to see whether the pump is acting freely; the water thrown from it should be in forcible intermittent jets; warm water with a little steam will frequently escape from it at first; if this should continue, it may be concluded that th upper clack does not act; and if the water is in a continuous stream without pulsations, the lower clack is out of order. In either case it will not be prudent to trust too much to the faulty pump, but the evil may frequently be remedied by working the pump a short time with the pet-cock open, or alternately turned on and off.

Coke is put on the fire by the Stoker, at the order of the Engine-man, who should hold the chain of the fire-door in his hand, and open it for as short a time as possible, while the Stoker throws on each shovelful of coke: the shovel should be well filled, and the coke distributed equally over the fire.

In most Engines, the fuel need not be higher than the bottom of the fire-door; and if allowed to fall more than 6 or 8 inches below it, it must not be expected that the pressure of the steam will be *maintained*, if the Engine has a load.

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of fuel required to keep up the fire

In other circumstances, prov
the fire is low enough to require
the best time to put on coke is

be laid on the fire, as it varies according to the duty to be done, and the water consequently to be evaporated: in cases of heavy duty and bad gradients, it may at times be necessary even at as short an interval as 2 miles; under contrary circumstances an Engine may sometimes run as much as 15 miles without adding fresh coke.

The fire should be allowed to run rather low before arriving at the top of an inclined plane down which the steam will not be used: on beginning to descend the plane, fuel should be put on the fire, which will burn up by the time the train reaches the bottom of the plane.

If it is wished to keep up the steam, it is better not to supply water and fuel at the same time.

While running, the Stoker should occasionally pick the ashes from the tubes to clear the draught.

of the Engine-man to

this view the regulator should n kept too far open ;—as soon as t has acquired the velocity wish aperture may be considerably r without diminishing the spee any diminution in the amo steam used causes a corresp diminution in the quantity consumed, the skill of the man should be unceasingly to the reduction of so heavy of Railway expenditure.

If there should be, at any

a short time, keep the regulator only partially open, and put on a gradual supply of coke.

When the water in the boiler is high, many Engines begin to prime, especially after running for several days. When this occurs, the aperture of the regulator should be diminished, and the fire-door and the discharge cocks of the cylinders opened: if the height of the water will allow it, the blow-off cock of the boiler may be opened for a short time to carry off the sediment, which will be found advantageous.

The Engine-man should frequently look to the working gear, to see that it is in proper order, and to rectify any deficiency at the next Station.

On nearing a Station where it is intended to stop, the regulator should be gradually eased off at about five-eighths of a mile from the Station, so that the *train* may be more under control, and when from a quarter to half a mile distant, according to the velocity and weight of the train, the steam should be completely shut off, and the train brought to rest by the breaks. In approaching terminal Stations the steam should be shut off at a greater distance than at the intermediate Stations, to prevent the possibility of overrunning the mark from the failure of breaks. It must be borne in mind that the breaks act much less efficiently in wet or frosty weather, when it becomes necessary to shut off the steam further from the Stations. The use of the reversing-lever ought, as much as possible, to be avoided: it may sometimes be placed in the middle position (in which the valves do not act), but it should never be completely reversed unless absolutely necessary for the stoppage of the train.

At the intermediate Stations, the *Stoker should* frequently oil all the bearings not supplied by the large oil-vessels, and fill the oil-cups of the connecting-rods, slides, &c., and if any of the bearings, brasses, &c., are hot, they should be more copiously oiled, and eased if necessary. He should also examine all the working gear cursorily to see if it is in a complete state; particular attention should be given to the axle-bearings, and especially those of the cranked axle, which sometimes become so hot by running as to require cooling by throwing on water.

In case of the driving wheels slipping much in starting from a Station, the opening of the regulator should be reduced, and only gradually opened as the wheel bites; the Stoker is sometimes obliged to scatter ashes, sand, &c., before the wheels: some Engines are now furnished with hoppers in *front*, opened by a handle from the

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tightened by screwing up the
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the permanent way,—and in descending planes whose inclination is sufficient to carry the train down, without steam, at a velocity of 30 miles per hour. In descending such an inclined plane, if it should be found that the velocity is greater than 30 miles per hour, it should be reduced by gently applying the break.

On every Railway there is a prescribed limit to the pressure of the steam, and no circumstance should induce the Engine-man to use steam at a higher pressure, or in any case to weight the lever, or hold it down for more than a moment. When there are two safety-valves, that which is out of reach may be set at the limit of pressure, and the valve next the foot-board some pounds lower. It is an advantage to have a stop placed below the lever of the safety-valve on the screw of the *spring* balance, to prevent its being inadvertently screwed down to more than the working pressure.

The steam whistle is obviously intended to give notice of danger: on this account its use is forbidden on some Railways, excepting on occasions of extreme emergency; but the variety of modulation of which it is susceptible has in others induced its adoption as a frequent warning. When the latter is the case, it has been found a safe measure to sound the whistle directly the steam has been shut off previously to stopping at a Station, and to give two short whistles the moment before starting, to warn parties of the approach and departure of the train. When this system is practised, the Engine-man should not turn on the full power of the whistle, but reserve it exclusively for cases of danger.

When near the end of the trip very *little fire* is wanted, and both feed-pumps should be turned on for a short distance before arriving at the Station, unless the Engine is to start again immediately. If it is intended to remain at the Station about an hour, the water should be considerably above the middle cock (when the Engine is standing), which will be effected by keeping on both feed-pumps from a half to three-quarters of a mile. The safety-valve should, at the same time, be eased off to 35 ℔s.

If the train is brought into the Station by a tow-rope, great care must be taken to stretch the rope gradually by a gentle advance of the Engine, which must be stopped at a signal from the tow-rope man.

It would be prudent to conduct the examination described at the commencement, directly the Engine arrives at the Station, in order to leave time for any repair which may be required.

When an Engine is running the last trip for the day, no fuel need be put on for the last 10, 15, or 20 miles, according as the duty is heavy or light; indeed, the fire may be nearly run out by the time the Engine stops, if the gradients, &c., are favourable. For a considerable distance before stopping both pumps should be at work, so that the water in the boiler may be at or above the top cock when the Engine stops, and the safety-valve should be eased off to 25 ℔s. per square inch.

On stopping over the pit, the fire is drawn by opening the fire-door, introducing the arrow-headed poker through the fire-bars, and pulling up two or three of them from the bottom of the furnace, by which room will be allowed for the rest to be separated, and the fire fall through into the ash-pan, from which it is raked out by the Stoker.

The practice of blowing off all the

water from a boiler by the pressure of the steam should never be allowed, without an express order from the Superintendent of Locomotives, when the boiler is unusually full of mud; as, if frequently practised, it will seriously injure the fire-box and tubes.

THE MANAGEMENT OF A LOCOMOTIVE ENGINE IN CASES OF ACCIDENT.

An Engine is liable to several accidents while running, and it is important that the Engine-man should know how to act promptly under the circumstances. In the following list several cases are enumerated, with the particular steps to be taken in each.

1. *The bursting of a tube.*—The Engine-man should stop the Engine, and drive a plug into each end of the tube. It frequently happens that the water and steam blow out with so much

force, that it is impossible even to discover the defective tube: by running the Engine for a short distance with both pumps acting, the pressure of the steam will perhaps be sufficiently reduced to enable the Engine-man to work with safety; but if the escape of water and steam is still too great to do so, he must run his Engine and train, if possible, off the main line into a siding, and draw the fire, to prevent its injuring the fire-box and tubes: when the water has run out down to the level of the defective tube, it may be easily plugged, and a fresh fire laid and lighted. A tube will frequently leak to a considerable extent without absolutely requiring the stoppage of the train; but in this case great care is necessary not to use much steam, or urge the fire too far.

The bursting of a tube or other *causes will* sometimes lead to the lagging or casing of the boiler catching fire, which should be extinguished by throwing on water from the Tender-cistern in a fire-bucket, or from the water crane at a Station.

2. *The failing of one of the feed-pumps.*—In this case the adequate supply of water may, with care, be maintained by one pump only. The supply of coke must be regular, and not in large quantities; and the steam must be economised, or the water may run low. The pump should be repaired as soon as possible; this may frequently be done in the interval between two trips.

3. *The breaking of a spring.*—This is an accident which does not necessarily involve the stoppage of the train; but as working the Engine in such a state causes an unequal strain, it should run very gently over rough parts of the road; and if the derangement is considerable, and cannot be repaired at

the Stations, the Engine should cease running as soon as possible.

4. *The breaking of a connecting-rod, or its disconnection* by the loss of cotters, fracture of the straps, &c. This accident, or any disconnection which allows the piston to be driven from end to end of the cylinder without restraint, causes expensive damage to the cylinders and covers; and the connecting-rod, if loose, will seriously injure the smaller gear, or may even throw the Engine off the road. The Engine should therefore be instantly stopped, and if possible the connection restored; if that cannot be done, the connecting-rod must be taken off, and if on a level or a descending gradient, the train may sometimes be drawn by a single cylinder: to do so, the slide-valve spindle of the defective cylinder *must be* detached from the valve gear, *by unscrewing* the nuts, and setting the

slide at the middle of its stroke so as to cover both ports.

If it should be found impracticable to move the train, the Engine might run on alone for assistance; but in any case where the Engine is obliged to remain stationary, the fire must be drawn directly the water is down to the bottom cock.

5. *The fracture or disconnection of the eccentrics, or any of the slide-valve gear.*—In Engines without hand-gear, if the connection cannot be restored, the attempt may be made, as in the previous instance, to work with one cylinder. When the slide-valve gear is disabled, Engines with hand-gear possess an advantage which others want, in being able to be worked by hand, when a single cylinder would be unequal to the duty, from not being able to move the crank over the centres at starting.

6. *The fracture of the strap which holds the slide-valve,* renders unavailable the cylinder on that side where it occurs, without affecting the other side. The slide should be detached and placed in the middle of its stroke, and the attempt made to work with one cylinder.

7. *The disconnection of a piston,* by the fracture of either cotter, is sometimes caused by shutting off the steam too suddenly when the Engine is travelling fast with a heavy load. In this case also the slide should be detached and set in the middle position, and the piston-rod uncoupled from the connecting-rod, which should be removed to prevent its damaging the small gear.

8. *The breaking of an axle,* in a four-wheeled Engine is an accident which is almost of necessity attended with the overturn of the Engine. In a

six-wheeled Engine it requires the stoppage of the train until assistance arrives.

9. *The Engine running off the rails.* With an Engine-man who drives carefully, watching well the position of the switches, and the signals given him, and stopping when he sees any danger attending his further course, this is an accident of very rare occurrence. If the Engine should run off on hard ground and near the rails, it may sometimes be lifted on again at once, by screw-jacks, crow-bars, and long sways; but if on soft ground or far from the rails, the fire must be drawn, and instant attention given to prevent its sinking deep into the ground.

The Engine should first be separated from the Tender, which, being a lighter weight, may be pushed out of the way, and leave more room for operating on the Engine; this, if it has fallen over on its side, should be lifted as quickly as may be into a vertical position; to do so, a purchase should be obtained under the framing on the lowest side, in two places if possible; two long and tough sways should be brought to bear on these points, and several men placed to weigh upon each; and as the Engine is gradually lifted by the sways, every movement should be followed up and supported by screw-jacks bedded on timber blocking. When the Engine has been lifted upright, it should be firmly supported by timbers placed as stanchions under the framing; the earth may then be cautiously removed from under the wheels, and a length of rail introduced, taking care to bed it as securely as possible on the blockings previously laid down, without disturbing them: the same process should be repeated on the other side, and cross sleepers driven in under both rails to secure the foundation. As soon as the Engine is in a vertical position and rails inserted under the wheels, a temporary railway may be laid down in continuation, and the Engine again drawn on the main line. It will much facilitate the raising of the Engine if the water is drawn away out of the boiler as soon as it is sufficiently cool.

In all cases of accident involving stoppage on the main line, it is of the highest importance that some person should immediately be sent back about three-quarters of a mile along the road, to give the proper signal of obstruction, and prevent any following train from running in unexpectedly.

The most essential personal qualifications of an Engine-man are, sobriety and steadiness, activity, presence of mind, and unceasing watchfulness; and wherever these are combined with an accurate knowledge of the construction of a Locomotive Engine and the principles of its management, they tend in no small degree towards rendering Railways, what they properly are, the safest as well as the most agreeable mode of travelling.

REGULATIONS FOR THE FIRST APPOINTMENT OF AN ENGINE-MAN, ADOPTED BY THE DIRECTORS OF THE LONDON AND CROYDON RAILWAY.

1840.

1. The candidate must not be under twenty-one years of age, and must produce a certificate of a sound constitution and steady habits.

2. He must be able to read and write, and, if possible, understand the rudimental principles of mechanics.

3. It will be a great recommendation if he has served his time to any mechanical art, especially as a Fitter of Locomotive Engines; and, if possible, he should produce testimonials stating his qualifications as such.

4. If the candidate has been a Fitter or a stationary Engine-man, he must,

for several months at least, have been a Stoker on a Locomotive Engine, under the direction of a steady and competent Engine-man; and before his appointment, he should produce a testimonial from the Superintendent of Locomotives, or at least from the Engine-man under whom he has served, stating full confidence in his acquaintance with the construction of an Engine and the principles of its management.

5. If the candidate has not been a Fitter or a stationary Engine-man, he must have served as a Stoker for at least two years, and produce the testimonials named in the preceding rules.

6. If required by the Board of Directors, for greater security, the candidate must undergo an examination from their Engineer, Superintendent of Locomotives, or other competent person, *as to his knowledge of an Engine and its management*, and the general result of

this examination must be committed to paper, signed by the examiner, and presented to the Board.

7. The Engineer or Superintendent of Locomotives of the Railway to which the candidate is desirous of being appointed, shall sign a certificate stating that he has conversed with him, has seen him drive, and has confidence in his steadiness and ability.

8. Before being allowed to take the entire charge of an Engine and train, the candidate must drive for several days under the direction of an experienced Engine-man, who must be on his Engine, and certify to his ability.

9. All certificates and testimonials must be deposited with the Secretary of the Company, who will restore them to the owner on his leaving their service.

⅛ Mile.	¼ Mile.	
Seconds.	Seconds.	Miles per ho
7·5	15	60·0
8	16	56·2
8·5	17	52·9
9	18	50·0
9·5	19	47·4
10	20	45·0
10·5	21	42·9
11	22	40·9
11·5	23	39·1
12	24	37·5
12·5	25	36·0
13	26	34·6
13·5	27	33·3
14	28	32·1
14·5	29	31·0
15	30	30·0
15·5	31	29·0
16	32	28·1

Time occupied in Travelling		Velocity.
⅛ Mile.	¼ Mile.	
Seconds.	Seconds.	Miles per hour.
19·5	39	23·1
20	40	22·5
20·5	41	21·9
21	42	21·4
21·5	43	20·9
22	44	20·4
22·5	45	20·0
23	46	19·6
23·5	47	19·1
24	48	18·7
24·5	49	18·4
25	50	18·0
25·5	51	17·7
26	52	17·3
26·5	53	17·0
27	54	16·7
28	56	16·0
29	58	15·5
30	60	15·0
31	62	14·5
32	64	14·1
33	66	13·6
34	68	13·2
35	70	12·8
36	72	12·5
37	74	12·2
38	76	11·8

39	78	
40	80	
41	82	
42	84	
43	86	
44	88	
45	90	

THE END.